(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 September 2006 (28.09.2006)

PCT

(10) International Publication Number
WO 2006/102409 A2

(51) International Patent Classification:
B65H 3/44 (2006.01)

(21) International Application Number:
PCT/US2006/010399

(22) International Filing Date: 22 March 2006 (22.03.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/088,385 23 March 2005 (23.03.2005) US

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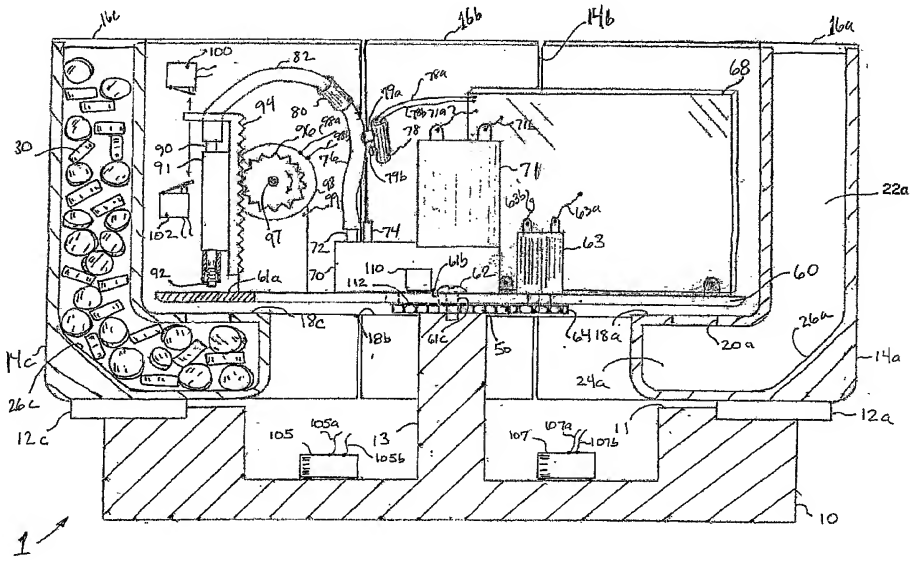
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: PILL DISPENSING APPARATUS



(57) Abstract: An automated pill dispenser includes a plurality of pill chambers peripherally disposed about a hub. The hub includes a rotatable plate capable of rotating to a selected pill chamber and removing a pill therefrom. A vacuum tip including a bellows extends through an access opening formed within the rotatable plate to withdraw a pill from a bottom portion of the selected pill chamber by grasping the pill from above. A reflective bar code is disposed beneath the rotatable plate and detectable through an opening through the plate to indicate plate position relative to the pill chambers. A computer enables a user to programmably operable the pill dispenser and select the pill chamber, dosage amount and time.

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PILL DISPENSING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is related to US application Ser. No. 10/438,452 filed May 14, 2003, the contents of which are hereby incorporated into this application by reference.

FIELD OF INVENTION

[0002] This invention relates generally to medication dispensers, and more particularly, to dispensers having the ability to dispense solid pill medications on a user programmed schedule.

BACKGROUND OF THE INVENTION

[0003] Pill dispensing systems that dispense pills according to a pre-programmed schedule are widely used and very valuable in today's society. It is advantageous for such pill dispensers to dispense different dosages of different pills at different frequencies and therefore at different times. Various pill dispensers are currently commercially available having multiple pill chambers and a means for dispensing pills contained within the chambers. However, each of these chambers contains only a single medication dose for a particular time. A single medication dose may include two, three or more different kinds of pill medication to be given at a particular time. Each pill chamber must then be individually filled with these different pill medications for a given particular time. For example, pill chamber 1 may contain two heart pills, a single antibiotic tablet and two cholesterol lowering pills all of which are to be taken by the user at 8:00 a.m. This type of pill dispensing system requires the chamber to be correctly filled with the various types and number of pill medication to be dispensed at a particular time. Thus if a user requires medication four times a day, twenty eight chambers must be individually filled by the user for one week's worth of medication. Additionally, the user is required to correctly count and place each pill medication into the correct pill chamber. This user intensive technique is prone to human error, makes it difficult to maintain the correct dispensing schedule

and dose, and further leads to increased health costs as the result of non-compliance.

[0004] As such, there is a need for an improved automatic pill dispenser that will reliably dispense the correct number of various pills at predetermined programmed times, provides for an easy and efficient means for placing the desired medication into the dispenser, extends the need to replenish the pill medication contained within the pill chambers from days to months, is not prone to failure or malfunction, is easy to manufacture and has a low manufacturing cost. The present invention is directed to overcoming the shortcomings of conventional pill dispensers and providing such an improved pill dispenser.

SUMMARY OF THE INVENTION

[0005] The invention provides an improved pill dispensing apparatus comprising a cylindrically shaped base unit having one or more pill dispensing chambers radially aligned along the outer circumference of the base. Each pill-dispensing chamber may include a removable top which protects the pills from air borne contaminants. Each pill dispensing chamber is further composed of a vertically positioned pill storage chamber for storing a large number of one particular pill type which then transitions to a lower dispensing chamber. A portion of the lower dispensing chamber partially protrudes towards the center of the base. The transition region between the pill storage and dispensing chambers is inwardly sloped to guide the pill medication towards the protruding portion of the dispensing chamber. The top portion of the lower dispensing chamber has a hole which allows internal access to the pill medication. Thus the pill chambers are arranged around the circumference of the base providing internal access to each stored pill medication. Additionally, at least one vibrating motor may be mounted on the base to gently vibrate the chambers and assist pill movement from the storage chamber to the dispensing chamber.

[0006] Axially mounted within the interior of the base is a disk shaped rotating platform which is powered by a set of gears and a first DC motor. As the platform rotates, a partially pie shaped hole located on the periphery of the platform allows access through each dispensing chamber hole to the respective pill medication.

[0007] Also affixed to the base unit may be a bar coded semi-reflective strip having reflective and non- reflective stripes. The pattern of stripes forms a unique code for each pill dispensing chamber. Further attached to the rotating platform may be an infra-red optical emitter and detector pair which cooperatively communicate with the bar coded strip. As the platform rotates with respect to the base unit, the optical emitter emits the infra-red emission from the transmitter which is either reflected or absorbed by the strip. The reflection from the strip is received by the optical detector which then produces an electrical signal corresponding to the bar code of each chamber. The electrical signal represents the relative position of the platform with respect to each pill dispensing chamber.

[0008] A DC powered suction pump having an inlet port in fluid communication with an outlet port may be further mounted on top of the rotating platform. When the vacuum pump is powered on, a vacuum is produced at the inlet port. The inlet port then connects to a flexible conduit which then further connects to the inlet port of a solenoid operable fluid switch. The outlet port of the fluid switch is in fluid communication with the atmosphere. Powering the solenoid establishes fluid communication between the atmosphere and the conduit which drastically reduces any vacuum present in the conduit. Further connected to the flexible conduit is the inlet port of a pressure transducer. The pressure transducer produces an electrical signal indicating the presence or absence of a vacuum in the flexible conduit. The flexible conduit then attaches to the top of a pill dispensing assembly.

[0009] The dispensing assembly further comprises a vertically positioned rigid conduit in fluid communication with the aforementioned flexible conduit at the upper end and in fluid communication with an attached flexible silicon bellow at the lower end. A springably biased vertically moveable sheath is concentrically located about the rigid conduit having the bellow protrude through the lower portion of the rigid conduit. A limit switch is positioned above the sheath and closes when the sheath reaches the uppermost allowed vertical position.

[0010] The pill dispensing assembly may be affixed to a vertically moveable rack which further engages a pinion gear powered by a second DC motor. The pill dispensing assembly is further located over the access hole of the rotating platform. Thus the dispensing assembly can move in either an upward or downward direction

through the platform access hole which has a position determined by direction of rotation of the second DC motor. Two additional limit switches are further placed at the furthermost allowable vertical top and bottom dispensing assembly positions and respectively close when the assembly reaches these positions.

[0011] A microcontroller is provided and interfaces to all three limit switches, pressure transducer, vacuum motor, table rotation first DC motor, vibration motors, dispensing second DC motor, opto emitter and detector, and solenoid valve. The programmable controller communicates with and controls the mechanical features of the pill dispenser. The microcontroller is further in electrical bidirectional communication with a single board computer having a touch screen liquid crystal display. The computer is programmably responsive to user input and includes a real time clock and associated memory.

[0012] It should be understood that the preceding mechanical description is exemplary only and that various suitable variations may be used.

[0013] In an exemplary embodiment, the user may enter a dispensing schedule by specifying the pill chamber (i.e., pill medication type), quantity of pills to be dispensed from the respective pill chamber and the time for dispensing the medication through an interactive dialog using the LCD touch screen. The single board computer controls the user interface through the interactive dialog and creates the dispensing schedule. Once the user has finished entering the dispensing schedule information, the computer then parses the dispensing schedule into a more basic schedule individually listing each time for dispensing an individual pill from a respective chamber. The single board computer is programmable and the time and/or the number of pills to be dispensed from each of the pill chambers may be programmably preset. The single board computer is operable to maintain a dispensing schedule of the pills from each of the respective pill chambers according to a predetermined dosage amount and a predetermined time. The dosage amount and time may include different frequencies and start times. When the time for dispensing the medication occurs, the computer sends the microcontroller a single pill dispensing command for dispensing only a single pill from a respective chamber. If more than one pill from the same chamber is required, another single pill dispensing command is repeated until the correct number of pills have been

dispensed from that pill chamber for that particular pill type. This procedure is continued until all pills from their respective chambers have been successfully dispensed.

[0014] The microcontroller is also programmable to operate the mechanism that withdraws the pills from the pill chambers. In response to a single dispensing command, the microcontroller places the dispensing assembly in the uppermost position as indicated by the closing the uppermost limit switch. The microcontroller then rotates the platform until the opto-circuitry indicates that the platform access hole is over the correct, selected pill chamber. The microcontroller then turns on the vacuum pump, vibrating motors and lowers the dispensing assembly through the platform access hole and into the pill chamber. If the flexible bellow engages a pill, a vacuum will occur in the fluid circuit. In response to the vacuum, the pressure transducer sends a signal to the microcontroller indicating that a pill has been picked up by the bellow. The microcontroller then raises the dispensing assembly and moves the platform over a release tray. The vacuum pump is then stopped and the solenoid switch activated removing the vacuum from the fluid circuit and releasing the pill. The pill subsequently falls under the force of gravity into the release tray. If a pill is not picked up, either the sheath switch or the lowermost limit switch signals the microcontroller. In response to either the sheath or lower limit switch signal, the microcontroller raises the dispensing assembly until the uppermost limit switch signals the microcontroller. The microcontroller again repeats the dispensing procedure for a number of programmed attempts, after which the microcontroller sends a "failure to pick up a pill" command to the single board computer. The single board computer then notifies the user audibly and/or visually using the LCD touch screen.

BRIEF DESCRIPTION OF THE DRAWING

[0015] A full understanding of the invention can be gained from the following description of the various embodiments when read in conjunction with the accompanying drawing in which:

[0016] FIG. 1 illustrates a cutaway view of an exemplary embodiment of the invention having a rack and pinion dispensing assembly;

[0017] FIG. 2 illustrates a top view of an exemplary pill dispenser;

[0018] FIG. 3 illustrates the dispensing platform;

[0019] FIG. 4 a illustrates a partially cutaway view of an exemplary vacuum dispensing system;

[0020] FIG. 5 illustrates an electrical block diagram of one embodiment of the invention;

[0021] FIG. 6 illustrates the parsing of the dispensing command from the single board computer to the microcontroller;

[0022] FIG. 7 illustrates an exemplary control algorithm for dispensing a single pill medication;

[0023] FIG. 8 illustrates a partially cutaway view of an exemplary vacuum dispensing system engaging a granular pill; and

[0024] FIG. 9 illustrates a radial dispensing assembly.

DETAILED DESCRIPTION

[0025] Referring to FIG. 1, a cutaway internal view of the pill dispenser 1 is illustrated having a support hub 10. Support hub 10, alternatively referred to as a support base, may be cylindrical in shape and has formed within top surface 11 mounting grooves 12a, 12b (not shown), 12c and 12d - 12f (not shown) which slideably accept and hold respective pill chambers 14a - 14c and 14d - 14f (not shown). Pill chambers 14a - 14f may be radially aligned along the circumference of hub 10 but other configurations may alternatively be used. Each chamber is formed to have respective vertically aligned pill storage chambers 22 and horizontally aligned dispensing chambers 24 that are substantially orthogonal to vertically aligned pill storage chambers 22. Each dispensing chamber has the capacity to hold a large quantity of one particular pill type. For an example, pill dispenser 1 as described herewith is composed of six pill chambers 14a – 14f and hence is capable of dispensing 6 different types of pill medication. However, the number of chambers can be increased by using a hub 10 with a larger circumference and/or radially

aligning more dispensing chambers around the base or using chambers of different dimensions. The inclined transition region 26 between chambers 22 and 24 of each dispensing chamber is formed to inclinably guide the flow of pills being pulled down chamber 22 by the force of gravity and into chamber 24. Each dispensing chamber is further formed to be interlocked with each other and mounted radially onto the outer circumference of hub 10 such that the entire dispenser 1 has a cylindrically shaped outward appearance. To protect the pills from dust and other air borne contaminants, each dispensing chamber is advantageously fitted with respective removable lids 16a - 16c and 16d - 16f (not shown). Pills 30 are contained within the pill chambers 14a - 14f. Although illustrated as having a conventional pill shape, the pills may take on other shapes in other exemplary embodiments. In one exemplary embodiment, the pills may be tablet-shaped or otherwise oblong.

[0026] Still referring to FIG. 1, the top of each dispensing chamber 18 has formed an access hole 20 (e.g. illustrated access hole 20a) which allows internal access to pills contained within chamber 24. Pill chambers 14 are preferably fixed to hub 10 and do not rotate. Not shown is release tray 15 and drawer 15a which are more fully disclosed in FIG. 2.

[0027] Hub 10 has further formed a cylindrically shaped support 13 axially aligned with the circumference of hub 10. Support 13 extends past top surface 18 of pill chamber 14. Affixed to support 13 is stationary spur gear 50. A semi-reflective strip 112 is circumferentially placed on the top surface of gear 50.

[0028] FIG. 2 is a top view of an exemplary arrangement of pill dispenser 1 that includes pill chambers 14a - 14f circumferentially disposed around support hub 10. Further shown is pill chamber 14c having respective lid 16c removed showing pills 30 stored within pill storage chamber 22c. For clarity, platform 60 and associated parts are not shown. Further shown are pill dispensing chambers 24a - 24f filled with their respective pills of various shapes. A peripherally disposed and inclined release tray 15 is positioned below pill chambers 14a - 14f into which pills are dispensed for the user to access by way of pull out drawer 15a. Pills withdrawn from chambers 24a - 24f are positioned over and then released into tray 15. The incline of tray 15 allows gravity to further urge the pills into drawer 15a. Arrows 15c note the typical dispensed pill path from tray 15 to drawer 15a.

[0029] Referring additionally to FIG. 3, cylindrically shaped dispensing platform 60 is rotatably attached to support 13 by pin 62. Platform 60 has further formed a pie shaped dispensing hole 61a, a square shaped optical access hole 61b and an axially positioned mounting hole 61c. The shape and orientation of holes 61a, 61b and 61c may vary in other embodiments. Affixed to the top side of platform 60 is electric motor 63. The shaft of motor 63 protrudes through platform 60 through hole 61d and is further attached to pinion gear 64 which is designed to mesh with gear 50. The diameter of pinion gear 64 is less than the diameter of gear 50 increasing the drive torque produced by motor 63 and also rotating platform 60 at a rotational velocity less than the motor shaft rotational velocity. Motor 63 is further electrically connected to printed circuit board 68 via wires 63a and 63b. Printed circuit board 68 is mounted to platform 60 and rotates along with platform 60. Powering motor 63 rotates platform 60 and also board 68 so that dispensing hole 61a is aligned over the dispensing chamber 24 of the selected pill chamber.

[0030] Further attached to platform 60 is diaphragm suction pump 70 having an inlet port 72 and outlet port 74. Power for pump 70 is provided via motor 71. Inlet port 72 is in fluid communication with tube 76. Attached to tube 76 is solenoid valve 78 having an inlet port 79a and an outlet port 79b. Inlet port 79a is in fluid communication with tube 76. The solenoid connects to printed circuit board 68 via electrical wires 78a and 78b. The outlet port 79b is in fluid communication with the surrounding atmosphere. The other end of tube 76 connects to and is in fluid communication with pressure transducer 80. The other end of pressure transducer 80 connects to and is in fluid communication with tube 82. The other end of tube 82 connects to and is in fluid communication with dispensing conduit 90. A flexible silicon bellow 92 is disposed on the other end of conduit 90 but other types of bellows may be alternatively used. Connected to conduit 90 is suction cup assembly 91 more fully explained below. Bellow 92, conduit 90, tube 82, transducer 80, tube 76, solenoid valve 78, inlet port 72, outlet port 74 and pump 70 form a fluid circuit and are in fluid communication with each other.

[0031] Conduit 90 is further vertically supported by vertically moveable rack 94. Rack 94 is positioned to engage a corresponding pinion gear 96. Pinion gear 96 is

affixed to shaft 97 of DC motor 98. Motor 98 is attached to platform 60 via support 99. Motor wires 98a and 98b connect to board 68.

[0032] Limit switches 100 and 102 are affixed to platform 60 by a bracket (not shown) or other means. These switches engage rack 94 at the end of the vertical travel of rack 94 having switch 100 engage at the uppermost end of travel and switch 102 engage at the lowermost end of travel. Switches 100 and 102 are also electrically connected to board 68 with wires (not shown).

[0033] Mounted on the bottom of hub 10 are vibrating motors 105 and 107. Motor 105 is electrically connected to board 68 via wires 105a and 105b. Motor 107 is electrically connected to board 68 via wires 107a and 107b. Vibration motors 105 and 107 are sized and accordingly powered to be capable of vibrating hub 10 and all pill chambers 14. Vibration motors 105 and 107 assist in altering the orientation of pills in dispensing chamber 24, making it easier for the pills to be grasped from above by the vacuum tip of bellow 92 of assembly 91.

[0034] Infrared optical emitter and detector module 110 is further attached to platform 60 and positioned over gear 50 so that module 110 is in optical communication through hole 61b with reflective strip 112. Module 110 is in electrical communication (not shown) with board 68.

[0035] Referring to FIG. 4, further detail of assembly 91 is depicted having bellow 92 inserted into conduit 90. Bellow 92 has further an open conduit 106 extending from the bottom through to the top of bellow 92. Thus fluid communication is continuous from the bottom (vacuum) tip of bellow 92 to port 74 of vacuum pump 70. Placed along the outside of conduit 90 is moveable shealth 108. Formed on the side of shealth 108 is slot 109. A pin 113 is inserted into slot 109 and is attached to the side of conduit 90. Shealth 108 is free to vertically move a predefined distance as shown by arrows 117. The extent of vertical movement is defined by the top end 109a and the bottom end 109b of slot 109. The bottom 114 of shealth 108 has further hole 115 which allows bellow 92 to freely protrude through and past bottom 114.

[0036] Affixed to the outside wall of conduit 90 is a push button single pole single throw sheath limit switch 120. Button 122 when depressed into the body of switch

120 closes the switch which in turn connects switch leads 124a and 124b. Leads 124a and 124b are further connected to board 68.

[0037] The upper end of compression spring 126 is attached to conduit 90 having the lower end engage the upper edge 128 of sheath 108. Thus sheath 108 is springably biased in the vertically extended position having pin 113 engaging the top end 109a of slot 109.

[0038] It is thus understood that assembly 91 moves in a vertical direction as depicted by arrows 130 independently of both sheath 108 and bellow 92 vertical displacements.

[0039] Referring additionally now to FIG. 5, an exemplary electrical block diagram of pill dispenser 1 is illustrated showing microcontroller 200 in electrical, bidirectional communication with single board computer 210 via bus 206. Microcontroller 200 has further random access memory (RAM) 201 and flash and EPROM memory 202. Memory 201 temporarily stores information received by computer 210. Memory 202 contains a dispensing algorithm used to control the dispensing of medication stored in pill chambers 14. In one exemplary embodiment, microcontroller 200 is part number MC68HC08GP32 previously manufactured by Motorola and now manufactured by Freescale Semiconductor, although it is understood that any suitable microcontroller having identical computing resources may alternatively be used as microcontroller 200. Computer 210 is in bidirectional electrical communication via bus 215 with touch screen LCD 220. User input and output communication 222 with computer 210 is via the touch screen and the LCD display panel respectively, both of which are incorporated into LCD screen 220.

[0040] Microcontroller 200 is preferably in further electrical communication with solenoid valve 78, dispensing motor 98, vibration motors 105 and 107, platform rotation motor 63, vacuum motor 71, pressure transducer 80, sheath limit switch 120, limit switches 100 and 102, optical emitter 110a and optical detector 110b of assembly 110 which are thus responsive to microcontroller 200. Power supply 230 supplies the necessary electrical power to all electrical block components shown in FIG. 5. It is further understood that the necessary interface power circuitry for

controlling the various motors from the microcontroller control signals is well known in the art and is therefore not included in FIG. 5.

[0041] Computer 210 is a single board computer and may advantageously be an Applied Data Systems part number AGX system having a 32 bit digital Xscale PXA250 RISC Intel processor running at 400MHz, 64 Mbytes of 100 MHz SDRAM, 128 Kbytes of EPROM, 64 Mbytes of synchronous flash memory, an ethernet 10/100BT interface, 22 digital I/O lines, three RS-232 serial ports, SPI communication port, real time clock and other peripherals. It is understood that this is exemplary only and other computers may be used in other exemplary embodiments.

[0042] Opto emitter 110a emits infrared radiation 111a which is reflected off of the surface of semi-reflective strip 112 and received by opto detector 110b. Stationary strip 112 contains a plurality of reflective segments and a non-reflective segment, in particular non-reflective bars 112a and reflective bars 112b that may form a bar code representing the relative position of platform 60 with respect to pill chambers 14a - 14f. It is understood that the relative position of assembly 110 with respect to strip 112 determines whether radiation 111a is either reflected or absorbed respectively by bars 112b or 112a, and therefore received by opto detector 110b as reflected radiation. Opto detector 110b then generates an electrical signal representative of the position.

[0043] In operation and now referring to FIG. 6, the user enters the amount of medication and the time for dispensing the medication. This procedure is more fully described in previously incorporated pending application Serial #10/438,452 filed May 14, 2003 and entitled Personal Medication Dispenser. Computer 210 receives medication dispensation request information via touch screen LCD 220 and generates a dispensing schedule 300. Schedule 300 further includes a sequence of time-ordered dispensing time blocks 307. Each time block 307 includes the dispensing time 310, pill chamber identification number 330 and the number of pills 320 which should be dispensed at time 310.

[0044] Computer 210 further parses schedule 300 into parsed schedule 340. Parsed schedule 340 is further comprised of a sequence of individual time ordered

dispensing blocks 315. Each block 315 contains the time 317 along with a single pill dispensing chamber number identification 319. Thus, time block 307 which requires two pills from chamber 1 is parsed into two blocks 315a and 315b each of which contains an individual instruction for dispensing a single pill from pill chamber 1. Computer 210 then compares the real time clock time with time 317 and if a match occurs, begins the transfer of the dispensing instruction 342 to microcontroller 200 via bus 206 at time t1. Thus microcontroller 200 is instructed to only dispense one pill at a time by computer 210. Dispensing instruction 342 contains the desired pill chamber 14 which stores the pill.

[0045] Referring now additionally to FIG. 7, upon receiving a dispensing instruction 342 from computer 210, microcontroller 200 begins execution of the dispensing algorithm 400. Before receiving the dispensing instruction 342, microcontroller 200 is held in wait state 405. At step 410, microcontroller 200 receives dispensing instruction 342 from computer at time t1 and then at step 420 echoes back the received command 343 to computer 210. Computer 210 then compares the echoed back command with the original instruction 342 and either issues an error and stops dispensing or allows microcontroller to proceed to step 425. In step 425, microcontroller 200 inputs the voltage on line 230a and checks whether switch 100 is closed. If switch 100 is not closed, microcontroller 200 outputs a command to motor 98 in step 427 to turn pinion 96 in a clockwise direction raising rack 94 and therefore assembly 91. Motor 98 is continuously powered until switch 100 closes. In response to switch 100 closing, microcontroller 200 shuts off motor 98 stopping the upward vertical movement of rack 94 and proceeds to step 430.

[0046] In step 430 and having previously positioned rack 94 in the most upward vertical position indicated by switch 100 closing, microcontroller 200 then activates opto emitter 110a. Opto emitter 110a emits radiation 111a which is either reflected or absorbed by strip 112. The reflected energy 111b activates opto detector 110b which sends a signal indicating the current position of platform 60 with respect to the desired pill chamber 14 previously received by microcontroller 200 from computer 210 in instruction 342. In step 435, microcontroller 200 then energizies motor 63 which in turn rotates platform 60 to position platform 60 and access hole 61a and select the pill chamber from which the pill or pills will be withdrawn. As platform 60

rotates, the relative position of platform 60 with respect to the pill chambers 14 is communicated to microcontroller 200 by optical assembly 110 and strip 112. When platform 60 is aligned with the selected pill chamber 14 having corresponding access hole 61a over dispensing chamber 24, microcontroller 200 in step 440 sends a command to stop motor 63, stopping platform 60. Hole 61a is now centrally aligned over hole 20 allowing assembly 91 vertical access to pills 30 contained within chamber 24. All other pill chamber access holes are covered by platform 60. Program flow then continues to step 445.

[0047] In step 445, microcontroller 200 initializes a RAM 201 memory register variable TRY to 5. Microcontroller 200 additionally turns on both pump motor 71 and vibration motors 105 and 107. Program flow then continues to step 447, in which microcontroller 200 turns on motor 98 which now rotates in a counterclockwise direction lowering assembly 91. Assembly 91 now begins a vertical downward decent through access hole 61a, hole 20a and into dispensing chamber 24a. Program flow now continues to step 450.

[0048] In step 450, microcontroller 200 inputs the signal on line 102a from switch 102. If line 102a is at a logic high indicating a switch 102 closure, program flow now proceeds to step 455 where microcontroller 200 immediately reverses the direction of motor 98 to clockwise direction raising assembly 91. A switch 102 closure indicates that assembly 91 is at the furthermost allowed vertical descent into chamber 24. This would occur for example if pill chamber 24 was empty. Program flow then proceeds to step 462. If switch 102 is not closed, program flow continues to step 457.

[0049] In step 457, microcontroller 200 inputs the signal on line 120a and checks the state of switch 120. If switch 120 is closed, program flow continues back to step 455. If switch 120 is not closed, program flow continues to step 460.

[0050] In step 460, microcontroller 200 inputs a signal from pressure transducer 80. If bellow 92 has engaged a pill in chamber 24 creating a vacuum seal in the fluid circuit; transducer 80 senses an increase in the vacuum pressure. Program flow then continues to step 480. If the signal from transducer 80 indicates the absence of a vacuum seal, program flow then loops back to step 450 via node A.

[0051] Referring now additionally to FIG. 8, bellow 92 is shown engaging the top surface of pill 500. Bellow 92 deforms to the surface topology of pill 500 and would normally create a vacuum seal. However, there are instances where bellow 92 is fully deformed and yet a vacuum seal is not formed. This situation may arise if bellow 92 engages a pill edge thereby having conduit 106 still partially opened to atmospheric pressure thus preventing a vacuum seal from forming. With bellow 92 fully compressed and a vacuum seal not formed, sheath 108 begins to move upwardly against the force of spring 126 and switch 120. Eventually switch 120 closes preventing the further downward motion of assembly 91 and the possible crushing or otherwise breakage of pills located beneath assembly 91. Further, the downward force of sheath 108 created by the force produced by compressing spring 126 acting on sheath 108 produces a downward directed force 505 on surrounding pill 501 forcing pill 501 away from bellow 92.

[0052] In step 462, microcontroller inputs signal on line 100a and checks if switch 100 is closed. If switch 100 is closed, program flow continues to step 464. If switch 100 is open, program flow loops back to step 455 raising arm assembly 91 until switch 100 does close.

[0053] In step 464, the variable TRY is decremented by 1. Program flow then continues to step 466.

[0054] In step 466, microcontroller 200 compares the current value of variable TRY to 0. If TRY = 0, program flow continues to step 470. In step 470, microcontroller 200 sends failure message 344 to single board computer 210 indicating that a failure has occurred after five attempts of picking up a pill. Microcontroller 200 then shuts off motor 98. If TRY does not equal 0, program flow loops back to step 447. The TRY variable can be set to any value and for illustrative purposes has been set equal to five.

[0055] Referring now to step 460, if bellow 92 picks up a pill a vacuum is established in the fluid circuit and transducer 80 sends a signal to microcontroller 200. Program flow then continues to step 480.

[0056] In step 480 and in response to transducer 80 signal, microcontroller 200 turns on motor 98 raising assembly 91. In addition, vibration motors 105 and 107 are shut off. Program flow then continues to step 482.

[0057] In step 482, microcontroller 200 inputs signal on line 100a and checks for switch 100 closure. Upon switch 100 closure, program flow continues to step 484. In step 484, microcontroller 200 turns off motor 98 thus stopping the vertical movement of assembly 91 and then turns on motor 63 rotating platform 60. Program flow then continues to step 486.

[0058] In step 486, microcontroller 200 inputs the signal from opto detector 110b and determines if platform 60 is at the correct position for dropping the picked up pill. The picked-up pill may preferably be dropped into a release tray such as release tray 15 shown in FIG. 2. The correct position for dropping the picked-up pill advantageously includes access hole 61a shown in FIGS. 1 and 3, aligned over an opening between dispensing chambers 24-24f providing vertical access to release tray 15. When the drop off position is reached, program flow proceeds to step 490.

[0059] In step 490, microcontroller 200 turns off motor 63 which stops the rotation of platform 63. Microcontroller then turns off pump motor 71 stopping the production of the vacuum in the fluid circuit. Additionally, to quickly release the vacuum and subsequently release the pill, microcontroller 200 turns on solenoid value 78 which allows the fluid circuit to be placed in fluid communication with the atmosphere. The previously held pill is now released and falls under the force of gravity from bellow 92 and into release tray 15 from where it is urged into drawers 15a and may be retrieved by the user/patient. Program flow continues to step 492.

[0060] In step 492, microcontroller 200 inputs the signal from pressure transducer 80 and determines if the fluid circuit still maintains a vacuum. Microcontroller 200 then waits until the vacuum is dissipated and then program flow continues to step 494. In step 494, microcontroller 200 shuts off solenoid valve 78 blocking the atmospheric pressure from the fluid circuit through port 79b. Program flow continues to step 496.

[0061] In step 496, microcontroller sends a success command 344 back to single board computer 210 via bus 206. Microcontroller 200 then is placed into a wait state

in step 405 where it is ready to accept the next sequenced parsed command 315b from computer 210.

[0062] FIG. 9 shows another exemplary embodiment of the pill retrieving mechanisms. Referring to FIG. 9, dispensing algorithm 400 can alternatively dispense pills using a radial arm for moving dispensing assembly 91 instead of the rack 94 and pinion 96 system. As illustrated in FIG. 9, attached to shaft 97 of motor 98 is a radial arm 600 which further attaches to assembly 91. Limit switches 100 and 102 are now positioned to to engage and limit the radial movement 605 of arm 600.

[0063] While specific embodiments of the invention have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to these details could be developed in light of the overall teachings of the disclosure. For example, an AC powered motor could be used in place of DC motor 98. Additionally, the number of chambers could be either increased or decreased by suitably enlarging the circumference of hub 10 or adjusting the sizes of the chambers accordingly. More or less than the exemplary illustrated six pill chambers may be used. Further, the power supply 230 could also include batteries. Accordingly, the particular arrangements disclosed are meant to be illustrative only and not limiting as to the scope of the invention which is to be given the full breadth of the appended claims and any and all equivalents thereof.

We claim:

1. A pill dispenser comprising:

a plurality of pill chambers peripherally disposed about a central hub, each of said plurality of pill chambers including a bottom portion, and

a mechanism that withdraws a pill from each of said bottom portions by grasping said pill from above, and delivers said pill to an exit port.

2. The pill dispenser as in claim 1, wherein said plurality of pill chambers are adjacent one another and circumferentially disposed about said central hub.

3. The pill dispenser as in claim 1, further comprising means for selecting a selected pill chamber of said plurality of pill chambers.

4. The pill dispenser as in claim 3, wherein said means for selecting includes a rotatable plate with at least an access opening therethrough and means for positioning said access opening over said bottom portion of said selected pill chamber, said mechanism disposed on said rotatable plate and withdrawing said pill from said bottom portion of said selected pill chamber through said access opening.

5. The pill dispenser as in claim 4, wherein said means for positioning comprises a computer and a motor that rotates said rotatable plate, said motor responsive to said computer.

6. The pill dispenser as in claim 4, wherein said plate is round and said access opening extends radially inwardly from a circumference of said plate.

7. The pill dispenser as in claim 4, wherein said means for positioning includes a stationary surface with a reflective portion and a non-reflective portion disposed beneath a detection opening formed in said rotatable plate, an optical source that directs light through said detection opening, and a sensor that senses light reflected off said reflective portion.

8. The pill dispenser as in claim 7, wherein said reflective portion includes a plurality of segments and said non-reflective portion includes a plurality of non-reflective segments together arranged in a pattern that forms a code indicative of

position of said rotatable plate with respect to each of said pill chambers which are in fixed position.

9. The pill dispenser as in claim 8, further comprising a programmable controller and means for sending to said programmable controller an electrical signal indicative of said position.

10. The pill dispenser as in claim 1, wherein each pill chamber includes a vertical portion that is essentially orthogonal to said bottom portion.

11. The pill dispenser as in claim 1, further comprising a plurality of said pills within said plurality of pill chambers and wherein each of said pill chambers includes a vertical portion and an inclined surface that guides pills of said plurality of pills from said vertical portion to said bottom portion.

12. The pill dispenser as in claim 1, wherein said mechanism is rotatable with respect to said plurality of pill chambers and said mechanism singularly and individually withdraws said pill from said bottom portion.

13. The pill dispenser as in claim 1, further comprising a plurality of said pills in said plurality of pill chambers and at least one vibrating motor that alters orientation of pills of said plurality of pills in said bottom portion and urges said pills into said bottom portions, each vibrating motor disposed in a base portion of said hub.

14. The pill dispenser as in claim 1, wherein said mechanism includes a vacuum tip and bellows portion that grasp said pill.

15. The pill dispenser as in claim 14, wherein said mechanism is mounted on a rotatable plate with an access opening therethrough, said vacuum tip extendable through said access opening and into said bottom portion.

16. The pill dispenser as in claim 15, wherein said vacuum tip is a terminal part of a tube that moves substantially vertically.

17. The pill dispenser as in claim 1, further comprising a computer that communicates with a programmable controller that communicates with said

mechanism, said computer including a timer and a memory and responsive to user input.

18. The pill dispenser as in claim 17, wherein said computer is operable programmably to preset at least one of a time and a number of pills to be dispensed from each of said plurality of pill chambers and to operate said mechanism to withdraw said pills from each of said bottom portions.

19. The pill dispenser as in claim 17, wherein said computer is operable to maintain a dispensing schedule of pills from each of said respective pill chambers according to at least one of a predetermined dosage amount and time, said dosage amount and time including different frequencies and start times, and to operate said pill dispenser to dispense said pills according to said dispensing schedule.

20. The pill dispenser as in claim 1, wherein said central hub is cylindrically shaped and respective outer surfaces of said plurality of pill chambers combine to form a circle.

21. The pill dispenser as in claim 1, wherein said exit port comprises a drawer disposed below said pill chambers and further comprising a centrally disposed inclined surface that urges said pill into said drawer.

22. A method for dispensing pills from a pill dispenser comprising:

providing a pill dispenser with a plurality of pill chambers peripherally disposed about a central hub, each pill chamber having a subjacent portion disposed below a retrieval mechanism;

selecting a selected pill chamber of said plurality of pill chambers;

rotating said retrieval mechanism to position said retrieval mechanism over said subjacent portion of said selected pill chamber;

withdrawing a pill from said subjacent portion of said selected pill chamber using said retrieval mechanism;

further rotating said plate to position said pill over a release tray; and

releasing said pill into said release tray.

23. The method as in claim 22, wherein said retrieval mechanism is disposed on a rotatable plate with an access opening therethrough and said rotating

includes positioning said access opening over said subjacent portion of said selected pill chamber and said withdrawing includes said withdrawal mechanism extending through said access opening.

24. The method as in claim 22, further comprising vibrating said central hub to alter orientation of pills in at least one of said pill chambers.

25. The method as in claim 22, further comprising a computer sending a signal to said pill dispenser to cause at least one of said rotating, withdrawing and further rotating.

26. The method as in claim 25, further comprising programming said computer using a touch screen.

27. The method as in claim 25, further comprising programming said pill dispenser to dispense pills according to a schedule including at least one of a dosage amount, dispensation time, and dispensation frequency.

28. The method as in claim 22, wherein said withdrawing comprises lowering a vacuum arm into said subjacent portion to grasp said pill from above.

29. The method as in claim 22, wherein said plate includes a detection hole extending therethrough, and a surface including reflective portions and non-reflective portions is disposed beneath said plate, and further comprising directing light through said detection opening and providing a detector capable of sensing reflected light from said opening.

30. The method as in claim 29, wherein said reflective and said non-reflective portions form a code indicative of a position of said rotatable plate with respect to each of said pill chambers, and wherein said rotating further comprises positioning said access opening over a desired subjacent portion based on said detector sensing said code.

31. A method for dispensing pills from a pill dispenser comprising:

providing a pill dispenser with a plurality of pill chambers peripherally disposed about a central hub, each pill chamber having a subjacent portion disposed below a portion of said central hub;

selecting a selected pill chamber of said plurality of pill chambers;

rotating a plate with an access opening extending therethrough, to position said access opening over said subjacent portion of said selected pill chamber;

withdrawing a pill from said subjacent portion of said selected pill chamber through said access opening; and

releasing said pill into a release tray.

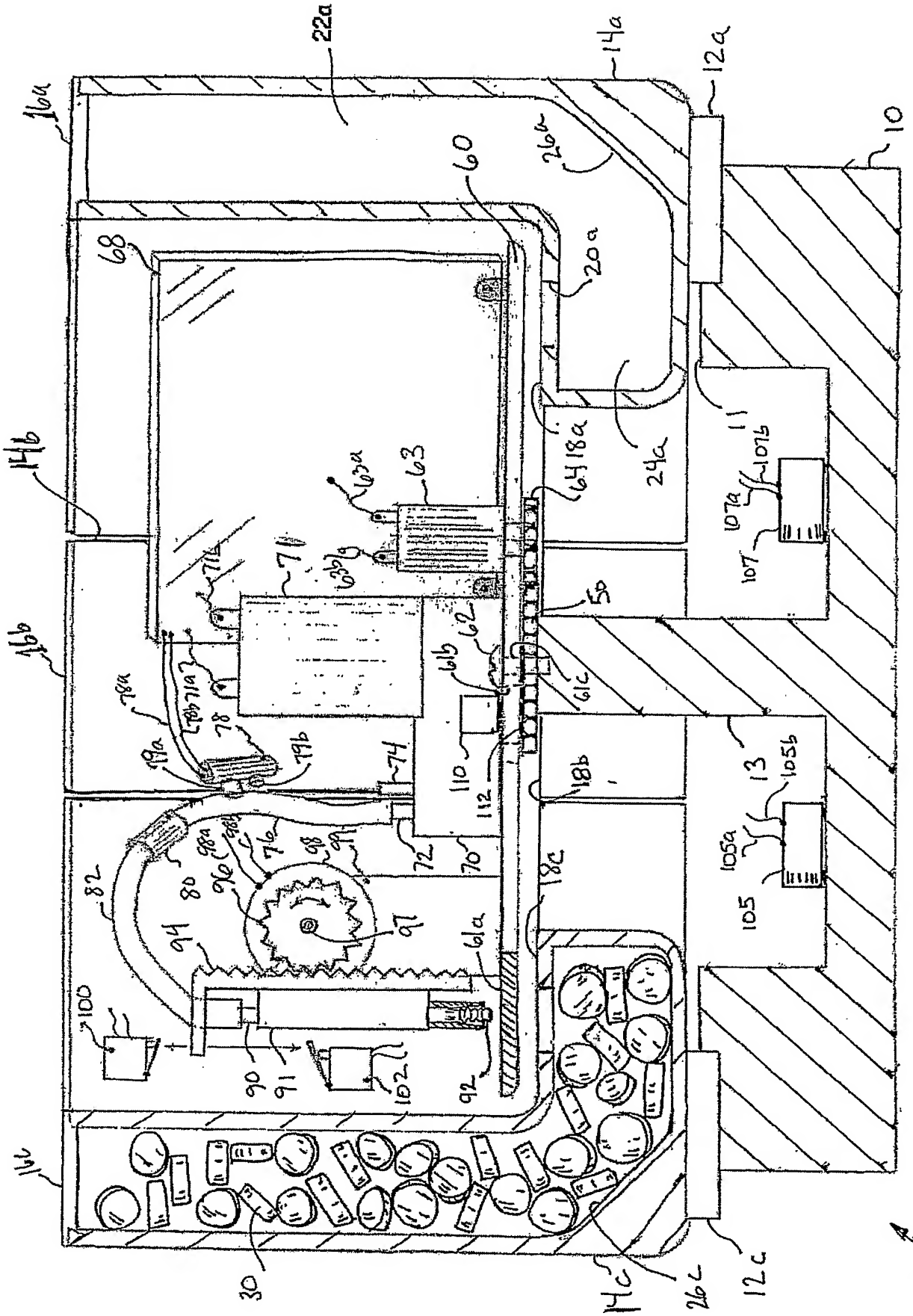
22a
14a
12a
16a
60
26b
10
68
20a
14b
24a
11
18a
64
63
63a
63b
107b
107a
107
50
71a
71
62
16b
61b
61c
78a
78
78b
74
110
112
18b
13
105b
72
70
18c
105a
105
82
80
76a
76
98a
98
94
97
61a
100
90
91
102
92
16c
30
14c
26c
12c
1

FIG. 1

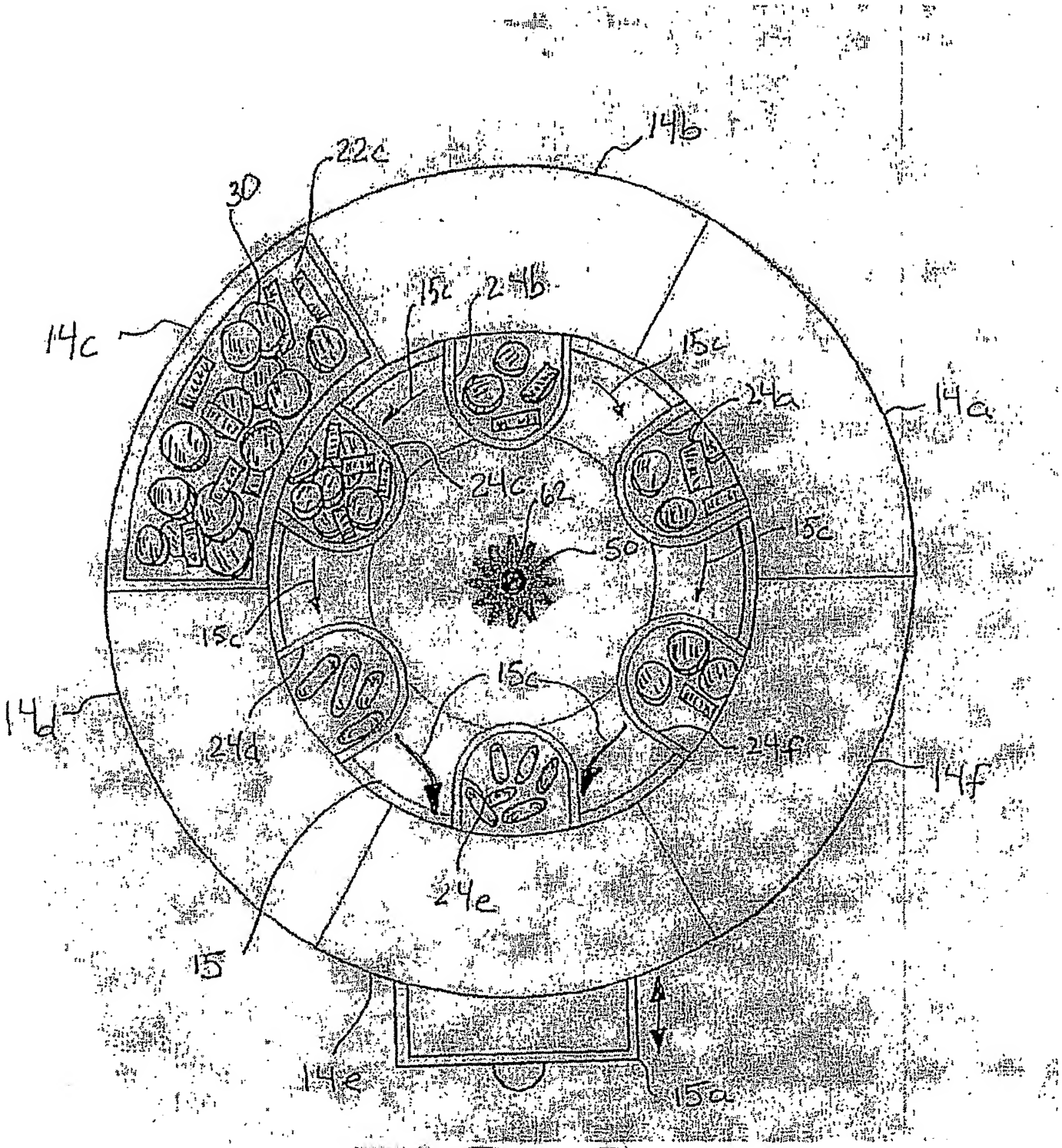
14b
22c
30
14c
15c
24b
15c
24b
14a
24c
62
50
15c
15c
15c
14d
24d
24f
14f
24e
15
14e
15a

FIG. 2

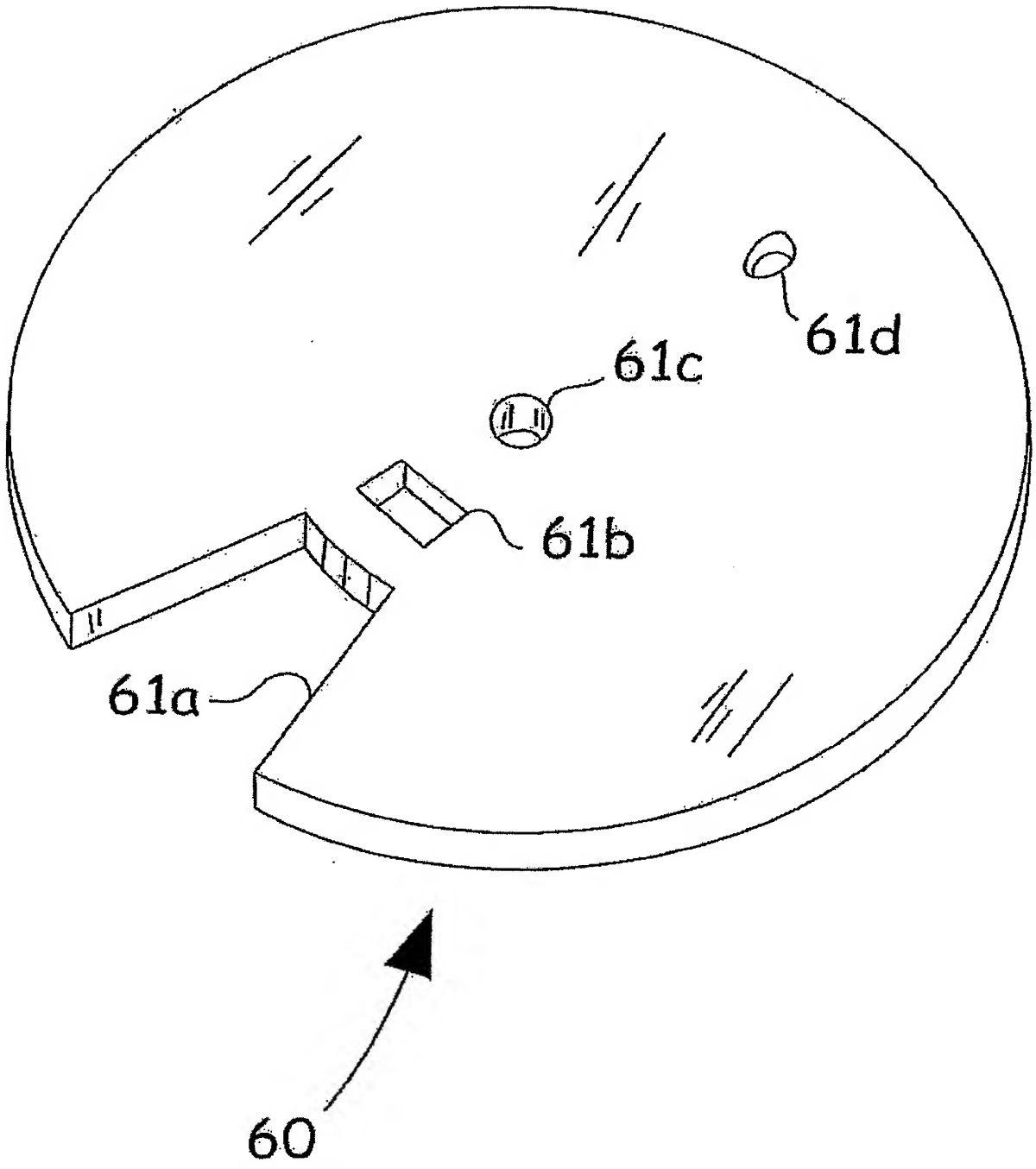

FIG. 3

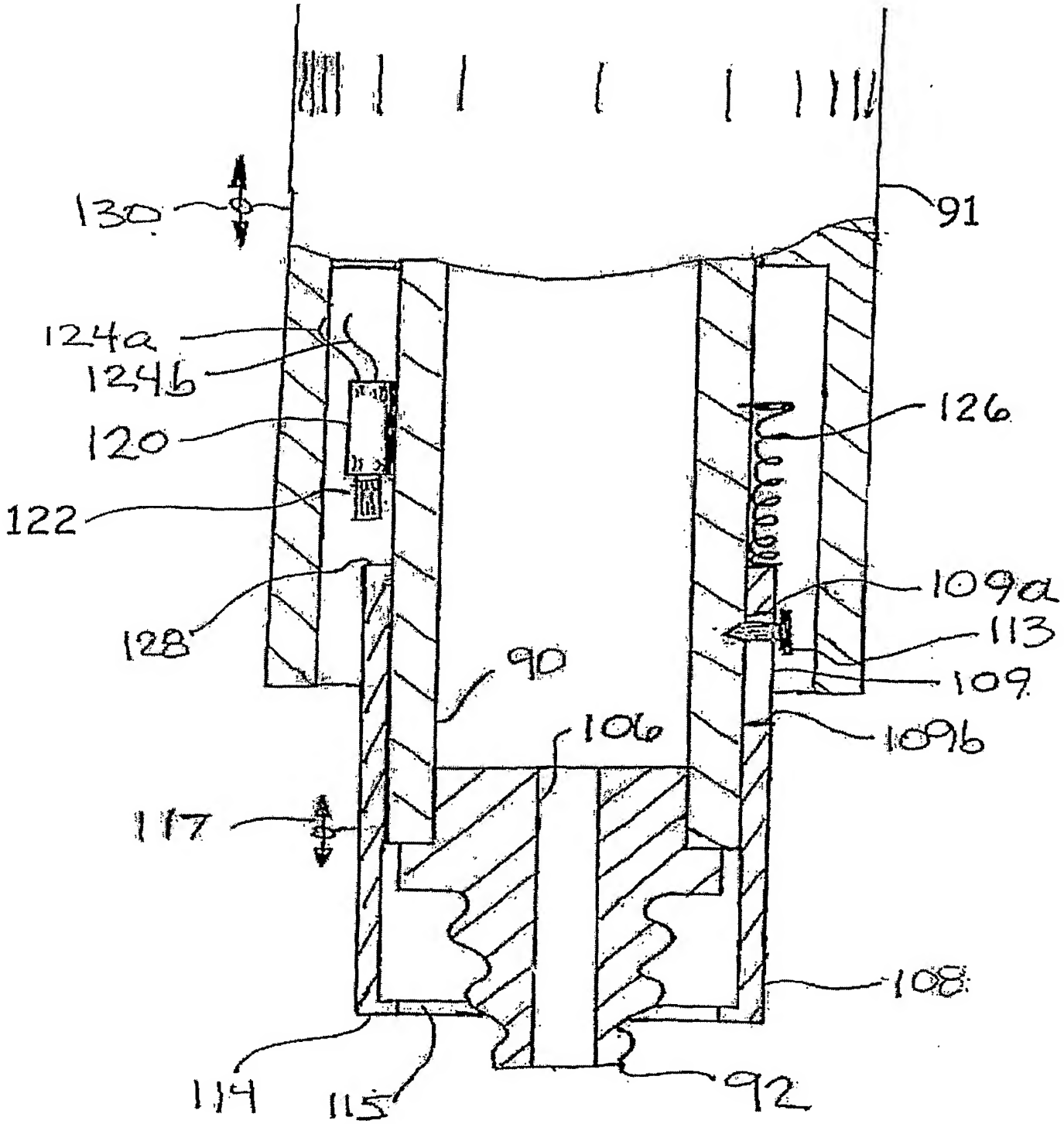
130
91
124a
124b
120
122
126
128
109a
113
90
109
106
109b
117
108
114
115
92

FIG. 4

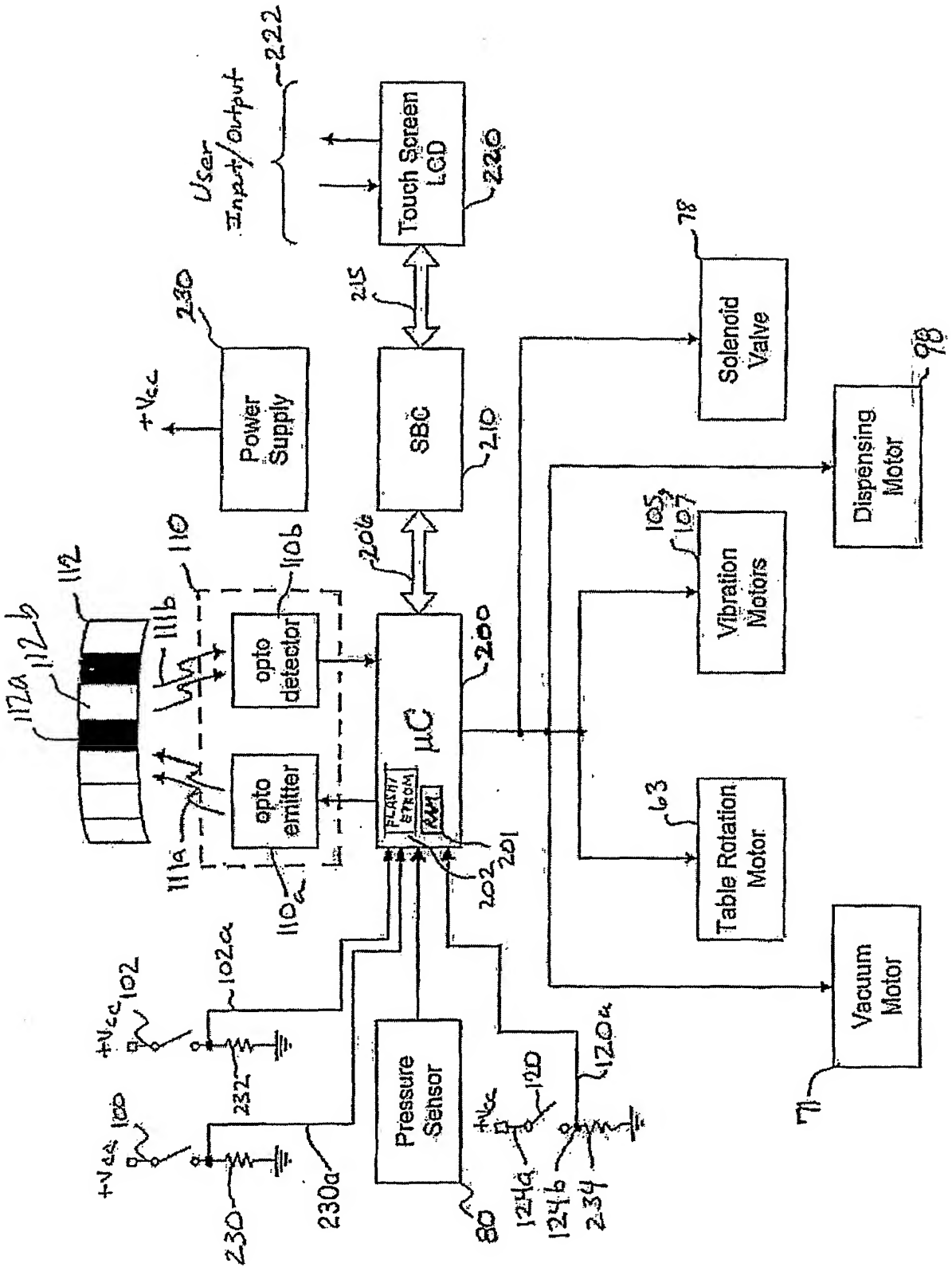
User Input/output
222
Touch Screen LCD
226
215
230
Power Supply
+Vcc
SBC
210
78
Solenoid Valve
98
Dispensing Motor
206
200
μC
FLASH/EPROM
RAM
201
202
opto detector
110b
110
112
112b
111b
112a
111a
opto emitter
110a
105
107
Vibration Motors
63
Table Rotation Motor
71
Vacuum Motor
102
102a
232
100
230
230a
Pressure Sensor
80
120
120a
124a
124b
234

FIG. 5

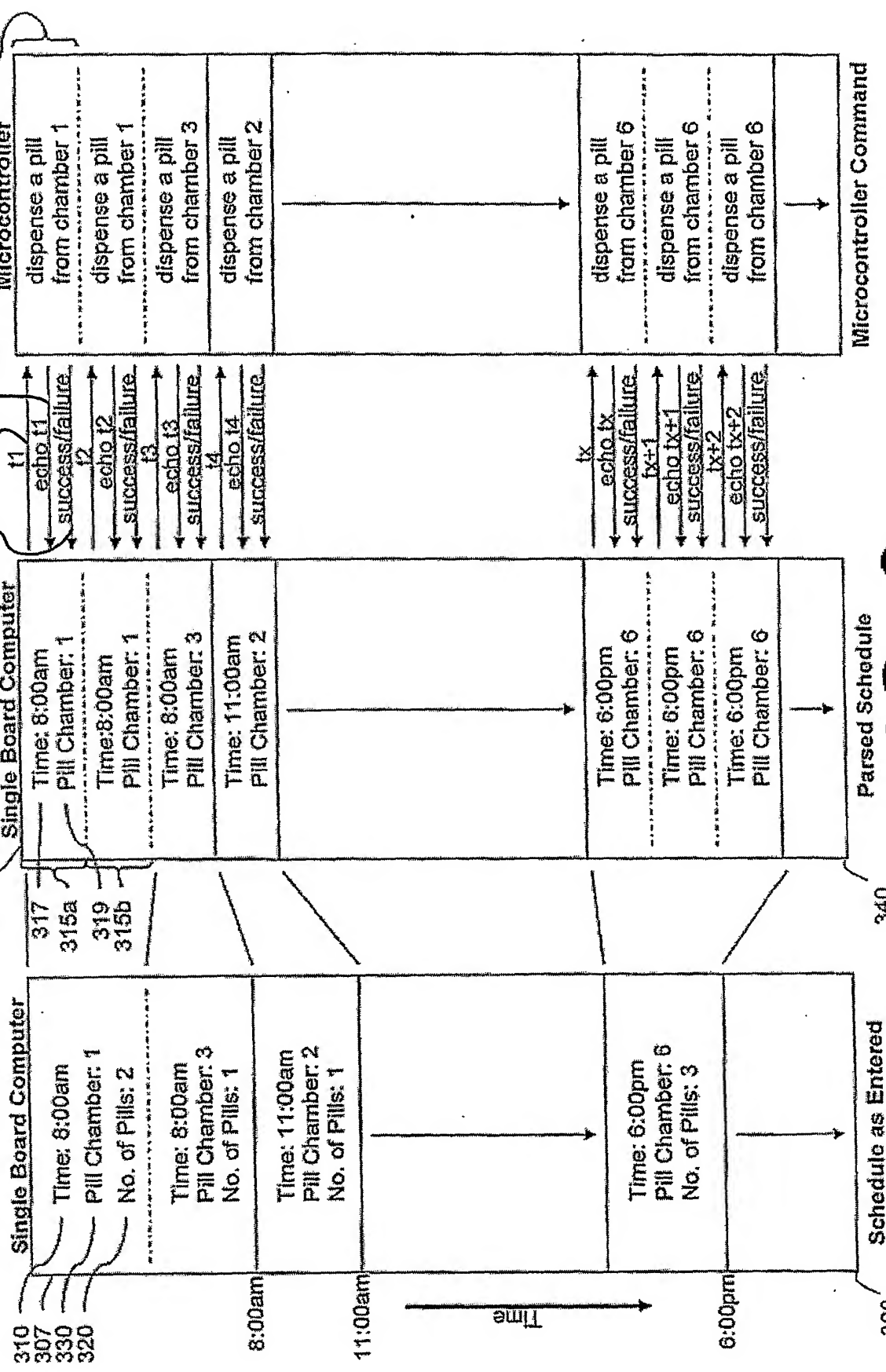
310
307
330
320
Single Board Computer
Time: 8:00am
Pill Chamber: 1
No. of Pills: 2
Time: 8:00am
Pill Chamber: 3
No. of Pills: 1
Time: 11:00am
Pill Chamber: 2
No. of Pills: 1
Time: 6:00pm
Pill Chamber: 6
No. of Pills: 3
8:00am
11:00am
6:00pm
Time
300
Schedule as Entered
315
317
315a
319
315b
Single Board Computer
Time: 8:00am
Pill Chamber: 1
Time:8:00am
Pill Chamber: 1
Time: 8:00am
Pill Chamber: 3
Time: 11:00am
Pill Chamber: 2
Time: 6:00pm
Pill Chamber: 6
Time: 6:00pm
Pill Chamber: 6
Time: 6:00pm
Pill Chamber: 6
340
Parsed Schedule
344
342
343
t1
echo t1
success/failure
t2
echo t2
success/failure
t3
echo t3
success/failure
t4
echo t4
success/failure
tx
echo tx
success/failure
tx+1
echo tx+1
success/failure
tx+2
echo tx+2
success/failure
400
Microcontroller
dispense a pill
from chamber 1
dispense a pill
from chamber 1
dispense a pill
from chamber 3
dispense a pill
from chamber 2
dispense a pill
from chamber 6
dispense a pill
from chamber 6
dispense a pill
from chamber 6
Microcontroller Command

FIG. 6

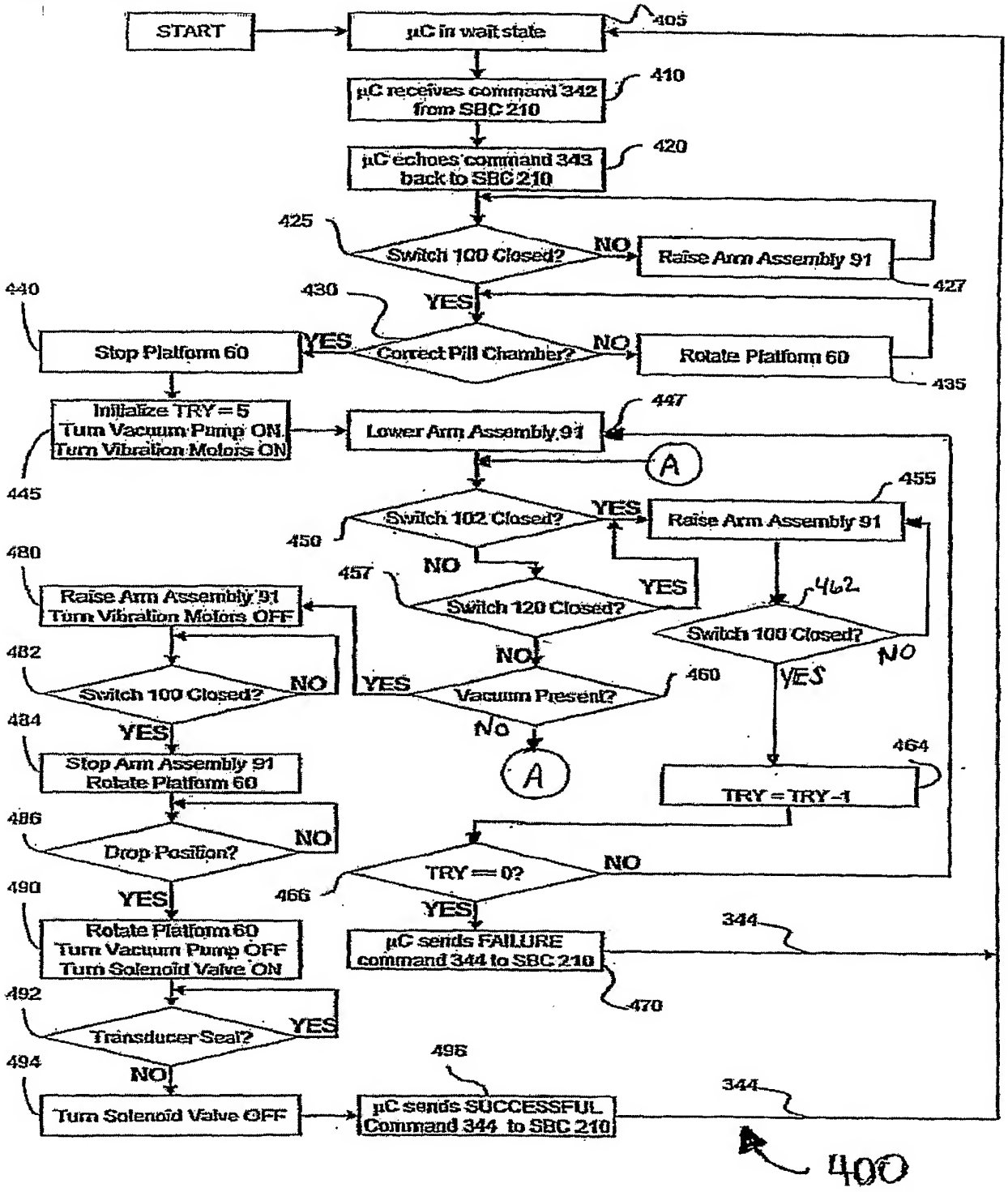
START
µC in wait state
405
µC receives command 342 from SBC 210
410
µC echoes command 343 back to SBC 210
420
425
Switch 100 Closed?
NO
Raise Arm Assembly 91
427
YES
430
Correct Pill Chamber?
YES
NO
Rotate Platform 60
435
440
Stop Platform 60
Initialize TRY = 5
Turn Vacuum Pump ON
Turn Vibration Motors ON
445
Lower Arm Assembly 91
447
A
455
Switch 102 Closed?
YES
Raise Arm Assembly 91
450
NO
457
Switch 120 Closed?
YES
462
Switch 100 Closed?
NO
YES
480
Raise Arm Assembly 91
Turn Vibration Motors OFF
482
Switch 100 Closed?
NO
YES
NO
Vacuum Present?
460
YES
484
No
Stop Arm Assembly 91
Rotate Platform 60
A
464
TRY = TRY-1
486
Drop Position?
NO
TRY = 0?
NO
466
YES
YES
490
Rotate Platform 60
Turn Vacuum Pump OFF
Turn Solenoid Valve ON
µC sends FAILURE command 344 to SBC 210
344
470
492
Transducer Seal?
YES
494
NO
496
Turn Solenoid Valve OFF
µC sends SUCCESSFUL Command 344 to SBC 210
344
400

FIG. 7

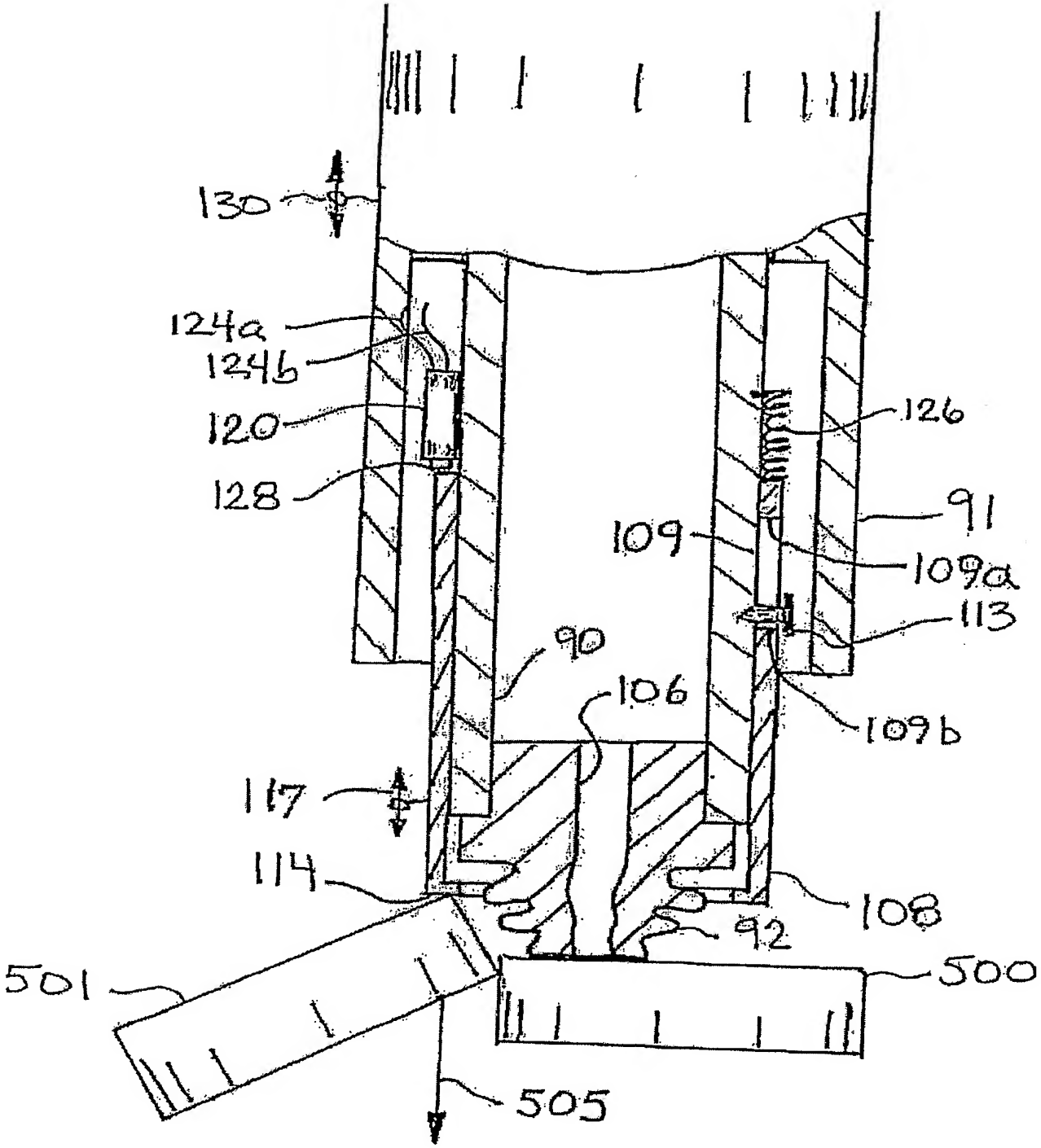
130
124a
124b
120
128
126
91
109
109a
113
90
106
109b
117
114
108
92
500
501
505

FIG. 8

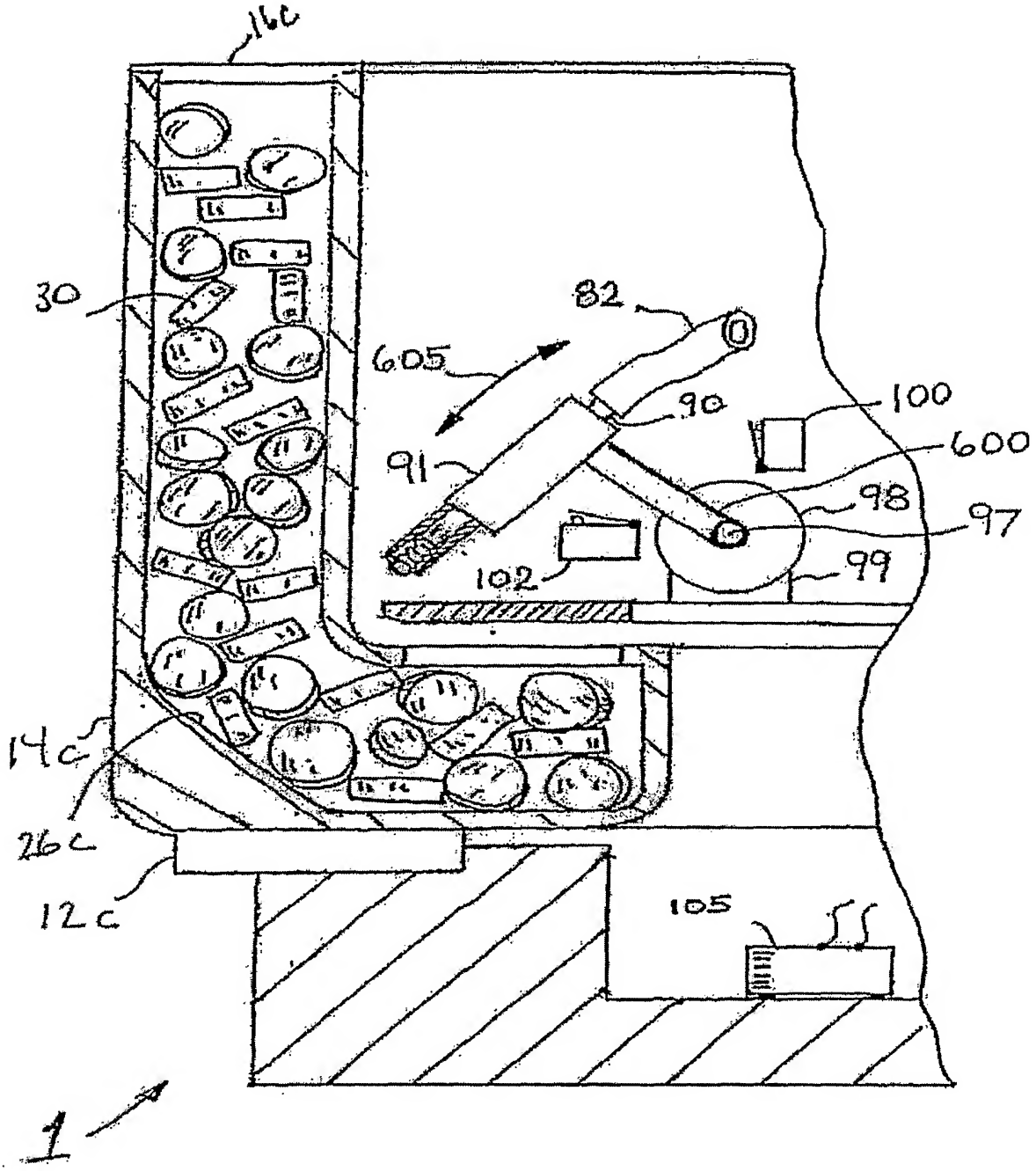

FIG. 9